DOCUMENT RESUME

ED 198 648 EA 013 416

TITLE	A Study in Energy Conservation for Existing Schools. Final Report.
INSTITUTION	Alberta Dept. of Education, Edmonton. Planning and Research Branch.; Calgary Board of Education (Alberta).
PUB DATE	79
NOTE	55p.
AVAILABLE FROM	Planning and Research Branch, Alberta Education, 11160 Jasper Ave., Edmonton, Alberta T5K OL2 Canada.
EDRS PRICE	MF01/PC03 Plus Postage.
DESCRIPTORS	*Computer Oriented Programs; *Cost Effectiveness; *Educational Facilities Improvement; Elementary Secondary Education; *Energy Conservation; Foreign Countries; Simulation
IDENTIFIERS	*Alberta

ABSTRACT

Phase 1 of this report summarizes a simulated approach to analysis of energy consumption in five selected Alberta schools. Phase 2, the greater part of the report, deals with the selection of cost-effective modifications in two schools representative of the greatest range of schools presently in the system. In each of the schools, the energy consumption was monitored, records kept of the costs of modifications, and an energy audit made to indicate how the total energy and utilities were apportioned within the school. The school statistical records affecting energy use are given with the energy audit. A major objective of this study was to supply a "shopping list" of items that would provide the greatest savings for the least investment cost. Items easiest to install and monitor were installed first, 18 modifications in one school, 29 in the other. These items, in ranking order of expense, constitute the energy saving shopping list of modifications. Also included is the application of the planning models to retrofit schools of a similar design. Guidelines for future school design are presented. (Author/MLF)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED198648

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

EA 013 416

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

W. P. Eddy

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

"A STUDY IN ENERGY CONSERVATION FOR EXISTING SCHOOLS"

Prepared Under Contract to Alberta Education

Edmonton, Alberta, Canada

- by -

Calgary Board of Education

- for -

Alberta Education
Planning and Research Branch

A STUDY IN ENERGY CONSERVATION FOR EXISTING SCHOOLS

FINAL REPORT

Prepared under contract to Alberta Education, Edmonton, Alberta.

PROJECT DIRECTOR

J. B. Delaney, Superintendent of Facility Services, Calgary Board of Education.

ACTION COMMITTEE

N. G. Patterson, P. Eng., Mechanical Engineer, Calgary Board of Education.

For investigation by Alberta Education Energy Conservation Steering Committee:

Dr. J. W. Kulba
Dr. W. E. Hathaway
Mr. I. Burn
Mr. M. Holt

COPYRIGHT NOTICE

The contents of this report may be used by Alberta Education without prior permission of Calgary Board of Education and may publish any parts contained herein on a royalty-free basis.

The Calgary Board of Education shall save harmless Alberta Education from all claims, demands, losses, costs, damages, actions or suits resulting directly from Calgary Board of Education improperly or incorrectly reporting or using information obtained in the course of this study.

Interpretation or adoption of the contents of this report shall be undertaken at the sole risk of the reader.

Copies of this report may be obtained on request from:

Planning and Research Branch
Alberta Education
11160 Jasper Avenue
EDMONTON, Alberta
T5K 0L2

TRUSTEES
Sam Blakely, Chairman
Scott D. Sevills, Vice-Chairman
Joan Fraser
Harold Gunderson
Catherine Martini
Alex Proudfoot
Joan Reid

SUPERIN
A. J. Longmore, Chief Sup
A. B. Cuppy, Planning & In
J. D. Delaney, Facility
G. L. Fowler, Instructional S
G. E. Holmes, Secretary-Tre
K. A. Jesse, Personnel Ser

Our File No.

Calgary Board of Education

December 21, 1979.

Alberta Education,
Planning and Research Branch,
Energy Conservation Steering Committee,
Edmonton, Alberta.

SUBJECT: A Study In Energy Conservation For Existing Schools, Phases I and II, Vol. I

We herewith submit our final report in accordance with the terms of our agreement made the 17th day of March, 1977, and subsequent agreements on the overall redirection of the study.

This report summarises:

Phase I (a) Reid Crowther Energy Analysis of 5 schools.

(b) Redirection of study to cover cost-effective modifications to two schools.

Phase II Installation and evaluation of modifications to two existing schools.

While summarising that which has already been submitted, the detail of this report deals mainly with Phase II and the methodology of produced results.

We have also continued to monitor the results of data up to the date of presentation of this report, however the best comparative data will continue to be produced in Jan. and Feb. of 1980. This is because one full year will have elapsed since we began data collection on this study.

The scope of this report is defined in the main body of this report as is the abstract, executive summary and chronology of events.

We thank you for the opportunity to present this report and trust you find the contents informative, useful and stimulating to continuing endeavours in the area of energy conservation.

Patterson

N.G.Patterson, P.Eng.
Mechanical Engineer,
Calgary Board of Education,
Architectural Services.

ARCHITECTURAL SERVICES DEPARTMENT
3610 - 9 Street S.E., Calgary, Alberta, Canada T2G 3C5

ACKNOWLEDGEMENTS

This report has been prepared by Facilities Department of the Calgary Board of Education in agreement with, and contract to Alberta Education consumated on 17th day of March, 1977.

Acknowledgement is made of the cooperation and effort of the following agencies and personnel who have contributed to completion of this report:

Alberta Education Steering Committee
Calgary Board of Education
- Architectural Services
- Operations Department
- Maintenance Department
- Management Information Services

Trial Programmes on Computer--Allan D. Patterson (Student), Computer Science, University of Calgary.

Information derived from bibliography listed at the end of report.

N. G. Patterson, P. Eng.
Mechanical Engineer
Architectural Services
Calgary Board of Education
3610 - 9th Street S. E.
Calgary, Alberta
T2G 3C5

Telephone: (403) 268-8552

ABSTRACT

This report summarizes the energy conservation programme to date, as instituted by Alberta Education in 1977.

The original plan and changes of emphasis since inauguration, are described elsewhere in "chronology of events."

This report is divided into two phases.

PHASE I (a) Deals with a summary of "Energy Conservation in Existing Schools" as prepared by consultants Reid Crowther and Partners.

(b) Deals with the redirection of the overall study to focus on two schools and the selection of cost effective modifications to those two schools.

PHASE II Deals with the installation and evaluation of the selected modifications. Phase II forms the greater part of this report and its scope is described separately after the table of contents.

This report is dedicated to serve the energy conservation needs of schools within the Alberta Education jurisdiction.

EXECUTIVE SUMMARY
PHASES I AND II

The study of energy conservation as originally instituted by Alberta Education, has been redirected in two places as follows:

PHASE I(a) - REID CROWTHER AND PARTNERS ENERGY ANALYSIS

The Reid Crowther Energy Analysis of five schools consists of a two-fold simulated approach to analysis of energy consumption in selected schools as requested by the Calgary Board of Education.

1. Obtaining a building audit of:

   a) The envelope;

   b) Mechanical/electrical systems;

   c) Operation of plant;

2. Proposal for building modifications and their effect on energy use.

PROCEDURE

The simulation consisted of:

a) Construction of a mathematical model representing the building and its components of energy use.

b) Simulation of the energy consumption based on an actual weather tape for a whole year.

c) Comparison of the simulated energy use with actual data on past consumption records.

d) Making modifications to energy-using components and simulate their effect on the base mathematical model.

The schools and their simulated modifications are listed as follows:

Briar Hill:
1. Existing building with windows blanked--present status.
2. Building with original windows as designed.
3. Windows blanked and insulated.
4. Hall lights off.

Roland Michener:
1. Existing building.
2. Reduced ventilation rates.
3. Variable air volume.
4. VAV and reduced lighting.

Lord Beaverbrook:

1. Existing building.
2. Reduced ventilation rates.
3. Triple glazing around courts.
4. Roof on courts.
5. Dual conduit system.
6. Fans off at 4 p.m.

Terrace Road:

1. Existing base building.
2. Insulated windows.
3. Insulated roof.
4. Outside air dampers closed at night.

Patrick Airlie:

1. Existing base building.
2. Windows blanked.
3. Windows blanked and insulated.
4. Additional wall insulation.
5. Increased roof insulation.
6. Outside air dampers closed at night.

Recommendations as a result of the simulated analyses were:

1. Lighting levels be reduced to recommended minimum.

2. Roof insulation be increased but only as part of re-roofing programme.

3. Wall insulation, insulated blanked off windows and mechanical system redesign all not recommended to be introduced.

Discussion items included general items such as:

1. Turning off systems when not in use.

2. Design of reheat systems not recommended.

3. Checking of existing system for operation as designed.

4. Do do reduce thermostate settings in zones.

5. Provide for changes in operation of systems as necessary.

Implementation. These are general recommendations on energy conservation procedures:

1. Obtain the services of a knowledgeable consultant.

2. Treat each school as individual model.

3. Conduct an energy audit.

4. Classify the school in terms of energy use.

5. Rank the school in terms of energy use.

6. Reduce energy-using components.

7. Commission the school a_z to completing design objectives.

8. Identify mechanical changes.

9. Investigate roof, window and wall insulation.

10. Establish an energy budget.

Critique. The Reid Crowther computer simulation approach is well presented and interesting because it emphasizes the basically different approach from the historical data philosophy presented in Phase II presented elsewhere.

This approach is about all that is available when a building is new and certainly the only approach when day to day energy consumption figures are not available.

The simulation approach, while being impressive, will lose most energy auditors in a multiplicity of data unless it is accepted without question. Questions do arise on items such as gas energy conversion efficiency of 80%, actual gas consumption data worked back from annual dollar costs incorporating two or more rate changes, and actual weather tapes which made no apparent note of percentile differences with actual year of comparison.

PHASE I(b) - REID CROWTHER AND PARTNERS ENERGY ANALYSIS

The redirection of the study of energy conservation to existing schools arose mainly as a result of the Phase I(a) study and its recommendations.

Extensive insulation of existing buildings was not viable unless done during a re-roofing programme, was the principal recommendation. The steering committee recommended that emphasis be placed on cost-effective and reasonably low cost modifications to existing schools. Then the study was redirected to provide an energy conservation service to the large majority of Alberta schools.

Two schools were selected as being representative of the greatest range of schools. Modifications introduced in these schools were to provide a shopping list that could be introduced by most school maintenance departments in Alberta. A preliminary list of modifications was made from calculations in conjunction with Phase I(a) recommendations. This list was greater in range and offered many energy-saving alternatives.

However, the problem to be resolved is to rank these modifications in terms which indicate the greatest cost-benefit, as well as the greatest energy saving components. Therefore, it was decided by the committee to

monitor the energy consumption and keep records of the costs of modifications to establish Return-on-Investment percentages.

PHASE II - INTRODUCTION AND EVALUATION OF MODIFICATIONS

The substance of this phase of the study is based on the belief that energy saving modifications are possible in most buildings, and that the most accurate information is obtained from "historical" data. This is data gleaned from computer inputs of energy consumption and building envelope statistics. Notwithstanding the substance of the Phase I(a) report which is a simulated programme, the Calgary Board of Education is in a unique position to evaluate approximately 200 school buildings of diverse as well as similar design on an "historical" basis.

A wealth of data can be obtained by a detailed daily analysis of energy inputs programmed to obtain specified outputs in terms of Energy Consumption per average temperature day (Degree Days) in conjunction with hours of use and other statistical data. While it is known that Degree Days are a somewhat inaccurate method of analysis when used over a monthly basis, it is believed that by using the daily cycle, more accurate data can be obtained. It logically follows that an hour by hour read-out will give the degree of accuracy that will be necessary in the near future.

With the empirical outputs thus obtained, it becomes apparent where the major energy-using components are. By introducing energy-saving modifications, it seems logical to chart the effects of the modifications by monitoring the revised data outputs on consumption savings.

One can foresee the time when more sophisticated controls will be used with digital alarm-type utility meters which will give an automatic indication if there is an excessive use of energy for longer than a prescribed period. The future also holds increased use of security and monitoring system which must overlap into the energy conservation area. The electronic age already offers amazing conservation area. The electronic age already offers amazing capability of detecting, correcting and monitoring systems which are having an accelerating effect on school building design.

This report is an initial step toward that objective of using the available tools and present-day acceptable technology. Habits will certainly change and technology must, of necessity, become more controlled to yield the results required in an energy-hungry world.

APPROACH TO STUDY

The detailed approach to installation and evaluation of modifications in existing schools consisted of selection of two schools which cover the greatest range of use within the system. The selection was also made so that a neighboring control school could be used for comparison purposes.

The two schools under study were determined as Briar Hill, planning Model No. 1, and Roland Michener, planning Model No. 2. An energy audit was

made to indicate how the total energy and utilities were apportioned within the school. Preliminary calculations were then made to estimate the most effective energy saving modifications and a schedule laid out for their implementation. Drawings and specifications were made for the Maintenance Department to install these items in conjunction with competitive bids from commercial contractors. Accurate cost records were kept.

Since late 1978, the Operations Department of the Calgary Board of Education had instructed all school caretakers to keep accurate records of utility usage on a daily basis. Weather department records from Calgary International Airport have been kept on regular basis for several months. As part of modification plans, measuring instruments were installed to record running times in conjunction with temperatures and pressures. Only the simplest of measuring methods are used to measure energy outputs. These are described for each planning model and an energy audit is established.

The contents of Volume I are intended to be a summary of information from detailed data collected in Volume II. Volume II data consisted of computer print-out on a daily and monthly basis. Calculations were made from the data and presented in summary form for the Volume I report.

The main object of data collection was to obtain consistent records of energy use in conjunction with weather and occupancy variables. It soon became apparent that this was a most complex exercise. Factors to establish the weather variables were most elusive and, of course, when applied to effects of modifications, a very conservative approach had to be made.

Monitoring weather effects from winter towards spring and summer was particularly hazardous, because the decreasing wind-chill factor and increasing solar factors made the modifications look extremely optimistic. This is where the comparison with neighboring schools was most valuable as downward trends of energy use per degree-day were matched and effects of modifications more clearly indicated.

Some of the proposed modifications had to be calculated, because the Maintenance Department was hesitant to implement some changes such as powered burners, before summer shut down. In addition, caretakers were already involved with an energy conservation program within the department, so items such as fan shut down were temporarily revoked to obtain estimates of energy usage. Generally, most modifications were made so that they could be revoked or reversed for test purposes.

Measurements of energy use were recorded as closely as possible under controlled conditions and predictable weather patterns. This was a laborious process and required "sitting in" for extended periods in the school premises. As could be expected, the effects of infiltration on the utilities yielded only approximate values.

Some surprising results were in early evidence as the energy audit progressed. By far the most significant energy waster is the single boiler plant. Even the duplicate boiler plant is not much better and there is strong evidence to suggest that multiple boilers and firing steps are necessary for optimum energy conversion.

Prime air movers are the next potential source of energy waste because of inferior dampers particularly on the outside air. Poor duct, damper and fan arrangements contribute to exhaust dampers being the source of as much as 30% induced air when fully shut! Constant air volume reheat systems have long been known to be energy inefficient, mainly because of the system of mixed air control which induces increasing quantities of outdoor air as the temperature rises (ASHRAE CYCLE No. 3). Prime air quantities are designed for summertime requirements and that is basically bad economy, hence, variable air volume systems are necessary.

Exhaust air must be viewed as a costly commodity. Exclusive of electrical energy, exhaust air costs 13¢/dm3/S this year for an average 8 hour 200 day school year in Calgary. This sounds trifling until we consider that an average modern school exhausts 1,416 dm3/S on a 14 hour basis and when 0.746 kw electrical energy is included this amounts to $400.00 PA. On this basis, the above mentioned school with 30% induced air incurrs costs of $950.00 PA.

Each planning model has a description of the measuring and monitoring procedure but a brief summary of results indicate the following:

Briar Hill model elementary school. Steam boiler (1) is only 25% efficient from gas input to condensate return.

Effects of modifications yielded savings of total energy input, of 20% for overall investment of $8,000.00.

Roland Michener model elementary school. Hot water boilers (2) are less than 50% efficient from heat output compared to gas input.

Effects of modifications yield savings of 20% of total energy input for overall investments of $12,000.00.

Conclusions. Based on the results obtained for the above two schools, being applicable to 120 Calgary elementary schools, approximate energy savings would be 13% for a utility saving of $200,000.00 PA.

CHRONOLOGY OF EVENTS

In this section, the major programme activities since the study was inaugurated in March 1977 are described.

The original guidelines were proposed by Dr. John Kulba in 1977 as follows:

Energy Conservation in Existing Schools, Calgary Public School District
To evaluate current energy conservation practices in existing representative schools and develop energy conservation programs and recommendations.

GUIDELINE OBJECTIVES

1. To use the computer energy programs to determine the effect that changes to the electrical, mechanical and building systems will have on energy consumption.

2. To study changes within the budget available and recommend changes that can be made to the selected schools and to all other similar schools with relatively similar impact on energy conservation.

3. To obtain and review operating schedules; equipment set points; operating personnel; school utilization schedules; simulate the operation of the building on the computer and compare predicted energy consumption with measured consumptions.

4. To hold consultations with Alberta Public Works and other agencies regarding established data and information exchange.

5. To co-ordinate efforts with Alberta Education and Alberta Housing and Public Works to assess energy use in schools and to develop a program aimed at improving energy performance.

On March 11, 1977, the proposal included a two phase program as follows:

PHASE I

(a) The first phase would be the preparation of an energy conservation report which would evaluate current energy conservation practises and produce programs and recommendations. By September 15, 1977, programs would be designed for selected schools.

(b) The second part of Phase I would be the actual implementation of the energy conservation programs in the three schools. Implementation would begin September 15, 1977 with final completion by April 15, 1978.

PHASE II

(a) Would consist of the monitoring and analysis of the programs implemented. By April 15, 1979, complete reports and results of the programs would be given to Alberta Education.

On January 16, 1978, Calgary Board of Education submitted to Alberta Education copies of the Reid Crowther Report on "Energy Analysis" of 5 schools, Briar Hill, Marlborough Park (Roland Michener), Lord Beaverbrook, Patrick Airlie and Terrace Road. One month later, an additional report was submitted on four schools, Briar Hill, Patrick Airlie, Roland Michener and Terrace Road summarizing energy saving modifications that could be introduced. At a meeting of steering committee held on that date, February 17, 1978, it was decided to concentrate on two schools, Briar Hill and Roland Michener.

A report was submitted to the steering committee on September 20, 1978, outlining proposed modifications to two existing schools, Briar Hill and Roland Michener. The committee endorsed these proposals and authorized the installation and monitoring of effects of changes.

In December 1978, the Planning and Research Department of Alberta Education published "Guidelines for Conserving Energy in Alberta Schools". This document outlined overall methods of energy conservation. The report by Calgary Board of Education was to be a more detailed supplement of the "existing building" aspects of energy conservation.

On January 26, 1979, a rough draft of the final Phase II report was submitted, outlining preliminary monitoring methods and results. The steering committee suggested that these procedures be incorporated and completed in a draft of the final report by April 1979. The publication of the final report to be ready by July 1979. The original intention to monitor results for a full year was waived to facilitate publication as close as possible to target date.

A draft of the final Phase II report was submitted on May 2, 1979. The steering committee recommended actions to rework the final report to include descriptions of Phase I and Phase II. A time extension was granted to include more accurate monitoring data, to summarize information from that data and to publish as Volume I. Detailed data to be collected for reference only in Volume II.

On December 21, 1979, the final draft of Phases I and II was presented to the Steering Committee. Volume I was submitted for publication by Alberta Education.

TABLE OF CONTENTS

Volume I

	Page
A STUDY IN ENERGY CONSERVATION FOR EXISTING SCHOOLS--VOLUME I	i
COPYRIGHT NOTICE	ii
LETTER OF TRANSMITTAL	iii
ACKNOWLEDGEMENTS	iv
ABSTRACT	v
EXECUTIVE SUMMARY--PHASES I AND II	vi
CHRONOLOGY OF EVENTS	xi
TABLE OF CONTENTS	xiv
SYMBOLS AND NOTATIONS AND UNITS OF MEASURE	1
PHASE II--SCOPE	1
AIMS AND OBJECTIVES--PHASE II	3
IDENTIFYING THE SCHOOL	3
IDENTIFYING THE ENERGY BALANCE	14
IDENTIFYING THE MOST PROMINENT ENERGY COMPONENTS	20
THE ENERGY BUDGET	20
IDENTIFYING THE ENERGY-SAVING MODIFICATIONS	20
SUMMARY INFORMATION--RETURN ON INVESTMENT	31
GUIDELINES AND RECOMMENDATIONS	31
ZERO-BASED BUDGET OF ENERGY	36
CONCLUSION	37
BIBLIOGRAPHY	38

SYMBOLS, NOTATIONS AND UNITS OF MEASURE

Units intended for use in this report are "SYSTEME-INTERNATIONAL d'UNITES" (S.I.). However, existing inputs of utilities are expressed as existing British Imperial and converted to S.I. units. There are other minor regressions to former units for reasons of clarity of communication.

General recommendations of CAN3-Z234 1-76 are herein adopted.

Area: m^2 - square meter is equivalent to 10.764 $ft.^2$.

Volume: m^3 - cubic meter is equivalent to 35.314 $ft.^3$.

m^3 - cubic meter is equivalent to 220 Imp. gals.

Volume Rate: dm3/S - decimeter ^{3} per sec. is equivalent to 2.119 CFM or 13.198 Imp. GPM or 15.85 US GPM

Pressure: Pa - pascals is equivalent to 0.004" WG.

Temperature: °C - degrees Celcius is equivalent to $\frac{(°F - 32)}{1.8}$

Degree Day: to base 18°C is approximately equivalent to $\frac{DD°F}{1.8}$

This is used to express average daily temperature in relation to an environmental temperature where no heating is required at 18°C (i.e., 10 DD°C. means that the average daily temperature is (18-10) or 8°C.

Energy: for this report ENERGY (which is also heat and work) is expressed in megajoules (MJ). 1 MJ is equivalent to 947.81 BTU. 1 MJ is equivalent to 0.278 kw. hours.

Power: is expressed in watts (or Kilowatts) and is equivalent to 1 joule per second and is also equivalent to 3.416 BTU hours.

Utilities: natural gas is metered in cubic feet (CF) or 1000 CF (MCF) and is converted to MJ. of energy. 1 MCF is equivalent to 1055 MJ.

Electricity: is metered in Kilowatt Hours = KWHRS.
1 KWHR is equivalent to 3.6 MJ.

Water: is metered in Imperial Gallons and 220 gals. is equivalent to $1m.^3 = 1000\ dm^3$ 1 imp. gal. = 4.546 dm^3.

PHASE II--SCOPE

This report complements the previously published "Guidelines for Conserving Energy in Alberta Schools" using two specific planning

models--Briar Hill and Roland Michener in Calgary. The report is in two volumes:

Volume I is summary results and "shoppinglist";
Volume II is detailed statistical data printout and calculations.

An information summary of statistical energy data and analysis of an implemented energy-saving set of modifications obtained from the school planning models is presented in this report. Also included is the application of the planning models to retrofit schools of a similar design. Guidelines for future school design are presented.

This report does not cover detailed recommendations for the building envelope such as roof insulation, nor does it cover recommended changes in operational habit patterns of teachers and students. These items have been reported elsewhere (1.2.3).

Only minor data on air conditioning are presented, because the principles of energy saving modifications relate to the heating season.

AIMS AND OBJECTIVES
--PHASE II

IDENTIFYING THE SCHOOL--Planning Models

Briar Hill Elementary - school statistics
- school occupancy variables

Roland Michener Elementary - school statistics
- school occupancy variables

IDENTIFYING THE ENERGY BALANCE

Energy audit.
Energy inputs.
Energy consumption.
Design heat losses.

IDENTIFYING THE MOST PROMINENT ENERGY COMPONENTS

The Energy Budget.
Comparison with other schools.
Comparison with Federal Budget.

IDENTIFYING THE ENERGY-SAVING MODIFICATIONS

Briar Hill model modifications.
Roland Michener model modifications.

PROVIDE SUMMARY INFORMATION

Return on Investment summary.
Shopping lists.

PROVIDE GUIDELINES AND RECOMMENDATIONS

Future trends.
Zero-base energy budget.
Conclusion.

IDENTIFYING THE SCHOOL

For information purposes, the school statistical records affecting energy use are given on the following pages. Their secondary purpose is to enable comparison with schools of similar design. The main reason why these two schools were selected for study is that they represent the greatest range of schools presently in the Calgary Board of Education

system. In addition, they also cover the old and the new design for periods circa 1950 and 1970. They represent changes in educational planning as well as increased demands in the standards of ventilation, individual area and comfort control. The present day designs also reflect the more efficient and flexible use of building and plant, incorporating greater community use.

The intention of the school statistics is to identify as many energy-sensitive components as possible. However, there is a real danger of grouping schools of apparent similar design and applying the results of this study haphazardly. It must be emphasized that each school has an identity of its own and the energy auditor must study the idiosyncracies of the individual school accordingly.

PLANNING MODEL--BRIAR HILL SCHOOL

There are more than 40 schools of the "Branton" design built between 1950 and late 1960's. These schools are "U" shaped schools with high frontage and glass to wall ratios of 20%. Construction is wood-frame and stucco surface with some brick around office frontages.

Roof insulation is 102 mm batt insulation plus 25.4 mm rigid insulation. Glazing is generally unsealed double glass wood frame. Gymnasium has 203 mm. square glass blocks.

The basic heating system is one central steam "Liberty" type boiler supplying perimeter unit ventilators and radiation with a central fan exhaust system serving each classroom. Moisture addition for humidity control is not provided.

Access for the piping is provided by 1.22m x 1.52m tunnels under the perimeter.

SUMMARY COMMENT

This can be described as a "solid" school found mostly in the inner city core. The high glazed frontages have recently been reduced to 13% because of the high solar loads and a Building Quality Restoration programme. Cooling is only adequate when the ambient temperature is below 15°C, and if the air intakes are well above paving to prevent induction of air from heated black aspalt surfaces. Unit ventilators are not now favoured, when considered in conjunction with latest HVAC equipment available.

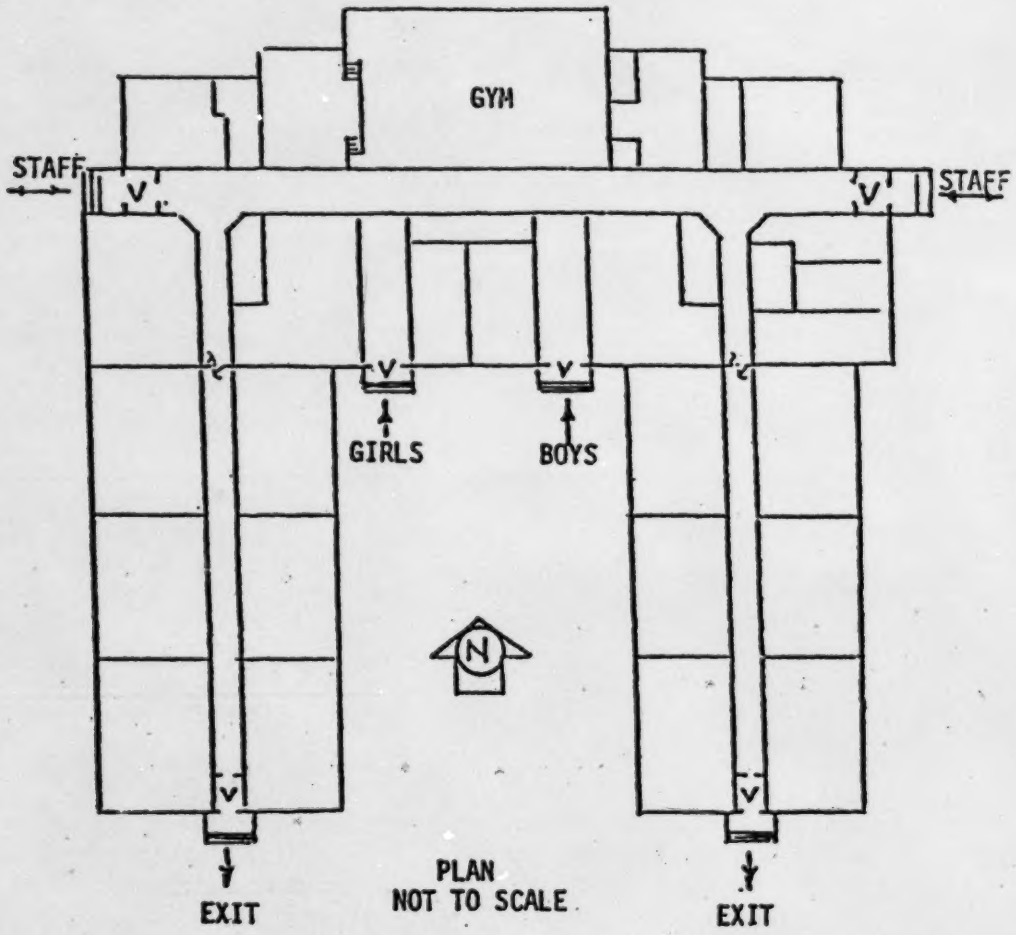
The following statistical sheet lists the main energy-sensitive components of the school.

SCHOOL STATISTICS AFFECTING ENERGY USE
The Building Envelope

Form S1
Jan/79

School: Briar Hill Elementary
Loc. No. 205
File No. 10
Address: 1233-21 St. N.W. (T2N 2L8)

Principal:
Caretakers:
Date Opened: September 1954
Additions: September 1955



PLAN
NOT TO SCALE

Roof Area: 2751m^2

Basement Area: 205m^2
Total Wall Area Above Ground: 1157m^2
% Wall Area Glass: 13

Tutorial Area: 1521m^2

Part Occupied Area: 891m^2
Doors: 5 DBL @ 3.85m^2 3 @ 1.93m^2 = 25m^2
: Perimeter - crack length = 78.6m
Weatherstripping at bottom of outside doors.
Relocatables at bottom of outside doors.
Relocatables Occupied: Nil
Relocatables Corridors Unoccupied: Nil
Notes:

Roof Insulation: 102mm Batt + 25.4mm rigid
U Value Roof: 0.397W/m^2/°C.
Glass Area: 152m^2
Combined Wall Glass U Value: 1.4/8W/m^2/°C.
% of Roof Area (Tutorial): 55.3
Gym and Stage Area: 339m^2
Vestibules marked "V" on drawing = 6

SCHOOL STATISTICS AFFECTING ENERGY USE

Mechanical Electrical Plant

School: Briar Hill — January 1979

Utilities:

Natural Gas	A/C No. 3299 02805	Meter No. 069198
Water	A/C No. 10-10 71215 1-8	Meter No. 11742986
Electricity	A/C No. 39-10 71215	X10 Powermeter No. 8703
Transformer 500 KVA		X60 Lightmeter No. 12057

School Lighting:

35330 Watts (% used during occupancy = 80)

Gymnasium Lighting:

7300 Watts (% used during occupancy = 100)

Outdoor Lights Signs:

Neg. Watts. Parking Plugs = 12,000 Watts

Heating:

Brownweld--Canadian Brown Steel Tank Company Limited, Brandon, Manitoba.

Steam Boiler:

Boiler No. 10,000 CRM 3824.2, CBST Company Limited SER 2741 STELCO 285C TS 55000 MWP 103 kPa steam H.S. 97m^2 Water 206 kPa CQ. 1953 A22445 Burner Triumph Series E. G.L. Ehman, Edmonton, Alberta, 711 mm chimney.

Univents:

Nesbitt 21 Off 23.446 Kw — Gym: 2 univents

Convectors:

38 @ 1.83 m long @ 4.395 Kw each
8 @ 1.22 m = 2.930 Kw each — Gym: 3 @ 1.83 convector 4.395 Kw each

Pumps:

Condensate 0.3346 dm^3/S
0.56 Kw 1800 RPM 3 PH

Sump Pump:

0.186 Kw.

Ventilation:

Supply fans Nesbitt Univents.
Exhaust fans 3.73 Kw 10590 dm^3/S
1160 RPM
2119 dm^3/S - Blow thru coils
6356 Dm^3/S 570 RPM low - Silavent sheldons B1 size 90 ARRGT 3 class 1

Gymnasium Units:

Roof top EXH 3 @ 1.83m Radn 2 Nesbitt 1.83m UV = 4238 dm^3S
0.56Kw 1180 dm^3/S TOTAL

Air Compression:

115V 0.37 Kw

Controls:

Pneumatic with Chronotherm Night set back.

Plumbing:

Total fixture units 186 SANI. 150 mm STORM 254mm
Sinks lavs. 36 Urinals 4 WC. 23 Showers --

DOM. HW TANK - John Wood 151 dm^3 10,840 Kw output 118 dm^3 Recov.

Irrigation:

12.7 mm Hosebibbs 4 places

- BRIAR HILL ELEMENTARY SCHOOL -

SCHOOL STATISTICS AFFECTING ENERGY USE
- OCCUPANCY, LIGHTING, OPERATION - October 1979

SCHOOL: Briar Hill Elementary 205 AREA INCL PORTABLES: 2412 m^2 GYM AND ANCIL AREAS: 339 m^2

SCHOOL CORE: PUPILS FULL DAY (PF): 103 ECS: 17 A.M. CLEANERS (CL): 2 CARETAKERS (CT): 2 TEACH STAFF (TS): 20

GYMNASIUM: DAY CLASS USE (DC): 22 YOUTH ACTIVITIES (YA): BROWNIES (BR): 15 CUBS (CB): ARTS-SCIENCE (AS): 15
FLOOR HOCKEY (FH): VOLLEY BALL (VB): SOCCER (SO): ADULT EDUCATION (AE): 14 CHURCH (CH): POLL STN. (PS):

DAY	FREQUENCY DAYS/MONTH	TOTAL SCHOOL AND GYMNASIUM USE		OCCUPANT HOURS PER DAY		UNOCCUPIED HOURS PER DAY	
		REGULAR HOURS	OTHER THAN REGULAR HOURS	SCHOOL	GYM	SCHOOL	GYM
	OCCUPIED / UNOCCUPIED	Pupils 5 — 515) Staff 7 — 140) ECS 2.5 — 43) OH Gym Classes — 100) Adult Ed. 5 — 70) School lights 80% 8.5 hrs. Gym lights 100% 3 hrs.	CL (2) 4-8 p.m. — 8 OH	THIS MONTH		THIS MONTH	
Mon.	4 / 1						
Tues.	5 / -	Ditto 768 OH	Ditto 8 OH	776	100	15	16
				3104	400	84	88
Wed.	5 / -	School lights 80% 8.5 hrs. School lights 10% 3 hrs. Gym lights 100% 6 hrs.	BR (15) 7-9 p.m. 60 OH) AS (15) 3-5 p.m. 30 OH) 103 OH CT & CL 13 OH)	776	100	15	16
				3880	500	75	80
				811	160	14.5	11
				4035	800	72.5	55
Thurs.	4 / -	Ditto Mon. 768 OH	Ditto Mon. 8 OH	776	100	15	16
				3104	400	60	64
Fri.	4 / -	No Adult Ed. 698 OH	Ditto Mon. 8 OH	706	100	15	16
				2824	400	60	164
Sat.	- / 4	-	-	-	-	24	24
				-	-	96	96
Sun.	- / 4	-	-	-	-	24	24
				-	-	96	96
Months Totals	22 / 9	School Lights Per Week 42.89 Hours	Gym Lights Per Week 20 Hours	16967	2500	544	543
Total Per m^2		School and Gym Lights = 0.4924 Kw Hours/m^2		7.0344	7.355	0.2255	1.6

Notes: OCCUPANT HOURS (OH) = Number of occupants multiplied by Number of Hours in attendance. UNOCCUPIED HOURS (UH) = when lights out and caretaker exists.

Summary: OVERALL OH/m^2 = 7.076

PLANNING MODEL--ROLAND MICHENER

These schools represent the modern trend toward "Core" type schools, having a basic 8 classroom core and planned addition of 8 relocatable classrooms on the perimeter. This basic core is built around the 24.4M X 30.5M gymnasium sized for future junior high school.

The structure is 203mm block walls and partitions with a ribbed steel upper structure above 102mm brick veneer. Windows are unsealed double glass with venetian blinds between and are limited to one window on perimeter classrooms only. Glass to wall ratio is relatively small as shown on the statistics. Roof insulation is 38mm rigid on roof and 25.4mm on walls. The mechanical plant is constant volume, single-duct central airconditioning and hot water reheat on the core. The gymnasium has its own free-cooling only, reheat sytem. The whole core has twin hot water boilers, radiation and individual room control.

Relocatables on this school are serviced by self-contained unit-ventilator air conditioning units with hot water heating coils piped from beneath the heated floor space.

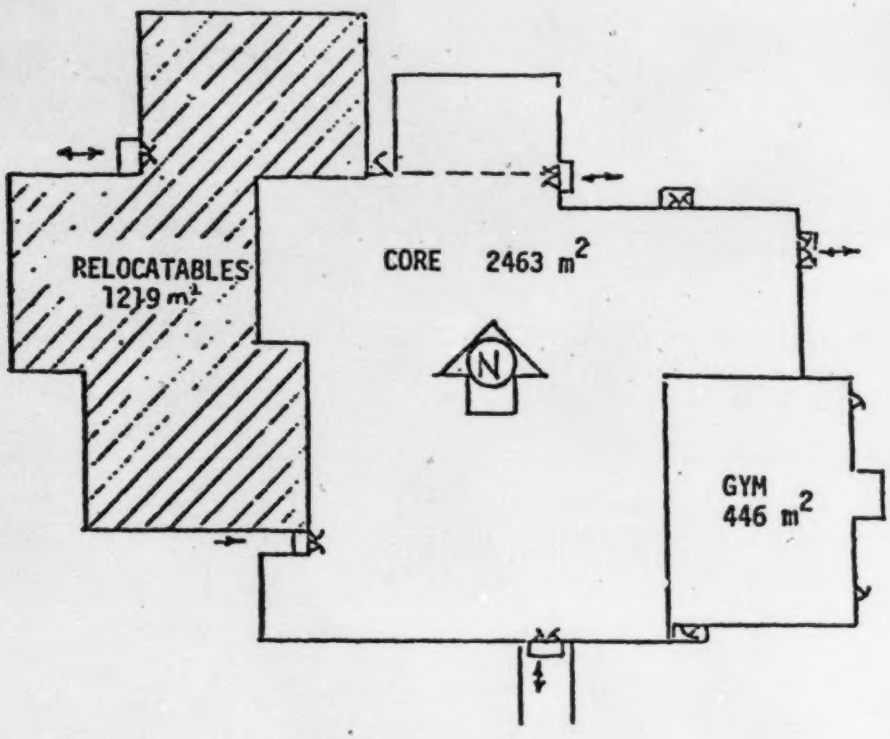
SUMMARY COMMENT

These schools comprise a group of 12 recently built from 1970 onwards. Each central air handling unit has a preheat coil mainly to service the large volumes of fresh air introduced in this area. Latest trends are to definitely limit costly fresh air to the legal minimum and also vary the supply air volume. The study of this planning model also verifies the need for revised mechanical systems.

SCHOOL STATISTICS AFFECTING ENERGY USE — Form S1
The Building Envelope — Jan/79

School: Roland Michener Elementary
Loc. No. 250
File No. 246
Address: 5958-4 Avenue N.E.

Principal:
Caretakers:
Date Built: November 11, 1976
Relocatable Addition: 1977



Roof Area Core & Gym: 2909m²
Basement Area: 127.7m²
Total Wall Area Above Ground: 1626m²
% Wall Area Glass: 1.47

Tutorial Classroom Area: 1207m²

Part Occupied Area: 418 + 836 = 1254m²
Doors: 5 Double + 4 Single = 27m²
: Perimeter crack length = 14 @ 6m = 84.7m
Weatherstripping bottom of doors only.
Relocatables Tutorial: 706m²
Relocatables Corridors Part Occupied: 513m²

Roof Insulation: 38.1mm rigid
U Value Roof: 0.567W/m²/°C.
Glass Area: 23.97m²
Combined Wall Glass U Value: 0.851 W/m²/°C
% of Roof Area (Tutorial): 41.5
Gym Area: 446m²
Vestibules: Nil

SCHOOL STATISTICS AFFECTING ENERGY USE

Mechanical Electrical Plant

School: Roland Michener Elementary January 1979

Utilities:

Natural Gas	2784 dm^3/S A/C No. 3299 18102	Meter No. 8703
Water	100 mm A/C no.	Meter No. 16539
Electricity	A/C No. 39-10-74015	Meter No. 50655
XFMR	3000 KVA	

School Lighting:

69,000 watts

% used during occupancy - 90

Gymnasium Lighting:

11,000 watts

% used during occupancy - 100

Outdoor light signs negligible watts

Parking Plugs - 18,000 watts

Heating:

HW Boiler

2 a Bryan CL 1800

Rated output Calgary 363 Kw

Preheat Coil

Trane 122 Kw at 9780 dm^3/S

Radiation:

Trane 125 116 m

Pumps:

1 @ EBARA 3.73 Kw 100 SFM 18.3 dm^3/S @ 129.4 KPa 1750 RPM D.D.
1 @ TACO 115 V. 0.062 Kw

Ventilation:

Supply fans 14.9 Kw
Trane No. 35
9780 dm^3/S
RA Fans 3.73 Kw
Joy 849dm^3/S 62 Pa

Gymnasium Units:

Trane PCC10A 2360 dm^3/S 311 Pa 3.73 Kw

Relocatable Units:

AAF SC UNIVENT 19.8 Kw 590 dm^3/S 13 Kw COOLING-ECONOMY

Cooling:

A/C Trane 162 Kw Nom.

Controls:

Pneumatic

Plumbing:

Total Fixture units 236 Sani. 150 mm Storm 305 Sinks Lavs. 33
Urinals 8 W.C. 18 Showers 10
Dom H. W. Tank RUUD GL 75-360-4 REC = 1136 $dm^3/Hr.$

Irrigation 51 mm

Note: Water kept running during February, March, April because of possibility of ground heave.

- ROLAND MICHENER ELEMENTARY SCHOOL -

SCHOOL STATISTICS AFFECTING ENERGY USE
- OCCUPANCY, LIGHTING, OPERATION - October 1979

SCHOOL: Roland Michener Elementary Loc. 250 AREA INCL PORTABLES: 3620 m^2 GYM AND ANCIL AREAS: 508 m^2

SCHOOL CORE: PUPILS FULL DAY (PF): 494 ECS: 43 A.M. 43 P.M. CARETAKERS (CT): 2 TEACH STAFF (TS): 26

GYMNASIUM: DAY CLASS USE (DC): 30 YOUTH ACTIVITIES (YA): 20 BROWNIES (BR): 25 CUBS (CB): 45 CUB SCOUTS (CS): 25
FLOOR HOCKEY (FH): 12 VOLLEY BALL (VB): 10 SOCCER (SO): 15 ADULT EDUCATION (AE): CHURCH (CH): POLL STN. (PS):

DAY	FREQUENCY DAYS/MONTH	TOTAL SCHOOL AND GYMNASIUM USE		OCCUPANT HOURS PER DAY		UNOCCUPIED HOURS PER DAY	
		REGULAR HOURS	OTHER THAN REGULAR HOURS	SCHOOL	GYM	SCHOOL	GYM
	OCCUPIED / UNOCCUPIED	Pupils 5 — 2470) Staff 7 — 182) ECS 5 — 215) OH Gym 3.3 — 100)	YA (20) 2 hrs. 50 OH) CT (1) 7 hrs. 7 OH) 107 OH FH (12) 2 hrs. 50 OH)				
		School lights 90% 8.5 hrs. Gym lights 100% 3 hrs.	CT (1) 7 hrs. = 7 OH VB (10) 4 hrs. = 80 OH 87 OH	THIS MONTH		THIS MONTH	
Mon.	4 / 1						
Tues.	5 / -	Ditto 2967 OH		2867	207	15	9
			CT (1) 7 hrs. 7) VB (10) 4 hrs. 80) 222 OH CB (45) 3 hrs. 135)	11468	828	84	60
Wed.	5 / -	Ditto 2967 OH		2867	187	15	9
				14335	935	75	45
			CT (1) 7 hrs. 7) CS (38) 215 hrs. 95) 102 OH	2867	322	15	9
Thurs.	4 / -	Ditto 2967 OH		14335	1610	75	45
				2867	202	15	9
Fri.	4 / -	Ditto 2967 OH	CT (1) 7 hrs. 7 OH	11468	808	60	36
				2867	107	15	9
				11468	428	60	36
Sat.	- / 4	-	-	-	-	24	24
				-	-	96	96
Sun.	- / 4	-	-	-	-	24	24
				-	-	96	96
Months Totals	22 / 9	School Lights Per Week 42.5 Hours	Gym Lights Per Week 35 Hours	63074	4609	546	416
Total Per m^2		School and Gym Lights = 0.7328 Kw Hours/m^2		17.424	9.073	0.1508	1.815

Notes: OCCUPANT HOURS (OH) = Number of occupants multiplied by Number of Hours in attendance. UNOCCUPIED HOURS (UH) = when lights out and caretaker exists.

Summary: OVERALL OH/m^2 = 16.395

IDENTIFYING THE ENERGY BALANCE

THE ENERGY AUDIT

To identify all the energy components of a total input and output (consumption) audit is the objective of an Energy Audit. The term "Energy Component" is defined as energy items converted or changed to useful purposes such as heat, light and mechanical output.

Energy has an efficiency of conversion to useful output which cannot be stored indefinitely and ultimately returns to the environment from where it came. Hence, the basis of an audit is that a balance exists between total inputs and outputs (or consumption). Of course outputs must also include inefficiences of conversion. This is where the Energy Audit differs from the Energy Budget since the latter does not balance with the total energy input.

For the purposes of Energy Audit then, the components shall be grouped as "INPUTS" and "CONSUMPTION" and shall be required to balance.

ENERGY INPUTS

The total items of energy input to a school building can be listed under the following general headings:

1. Natural Gas Fuel Energy - Heating Main Core
2. Natural Gas Fuel Energy - Heating of Relocatables
3. Natural Gas Fuel Domestic Hot Water Heating
4. Electrical Energy - Lighting - Main Instructional and Occupied Areas
5. Electrical Energy - Corridors, Emergency and Service Areas
6. Electrical Energy - Outdoor Lighting
7. Electrical Energy - Power Motors Inductive Loads
8. Electrical Energy - Power Equipment, Kilns and Internal Resistive Loads
9. Electrical Energy - Power Car Plug-Ins and External Resistive Loads
10. Solar Energy - Roof Absorptivity
11. Solar Energy - Walls Absorptivity
12. Solar Energy - Windows Transmittance
13. Occupants - Heat Gain
14. Ventilation and Infiltration Energy - Enthalpy of Outdoor Air
15. Water Energy - Total Heat of Domestic Water

The foregoing are in approximate order of intensity and depend on summer or winter mode of calculation. Input energy must equal the output (or consumption) of energy.

ENERGY CONSUMPTION

Those components deemed most constant are listed first. The potential for upgrading all factors is acknowledged, but in order to accomplish an energy audit, an effort must be made to isolate the components as accurately as possible. The emphasis here is on winter losses.

1. Boiler (or heat transer medium) combustion efficiency. This also includes the effect of altitude.
2. Roof heat losses, (related to indoor-outdoor average temperature difference).
3. Walls heat losses.
4. Windows heat losses.
5. Ventilation - controlled.
6. Ventilation - exhaust fans.
7. Ventilation - infiltration.
8. Boiler (or heat transfer medium) over-sizing factor.
9. System design - control method.
10. Weather secondary factors - snow, windchill, rain.
11. Occupants - heat lost on existing.
12. Drainage - storm and sanitary losses.

ENERGY BALANCE--BRIAR HILL MODEL

From school statistical data Forms S1, S2 and 01, and using a typical day, Friday, February 23, 1979, we obtained the following data based on the knowledge of:

1. Degree days 41.1 E. wind average 10 Km/Hr. 2.4 hrs. sunshine.
2. Average ambient temperature -23.1°C. Snow on ground 9 cm.
3. Indoor temperature 8 a.m. to 4:30 p.m. = 21°C (70°F).
4. Indoor temperature during night set back 18°C (64°F).

INPUTS--24 HOURS

Utility - Natural Gas Consumption 25,220 Ft.^{3}

			MJ	% Of Total
Steam boiler main burners	23,113 Ft.^{3}	=	24,386	81.77
Steam boiler pilot flame	1,774 Ft.^{3}	=	1,872	6.28
Domestic hot water heater	333 Ft.^{3}	=	351	1.18
Domestic hot water--water heat to building	25 Ft.^{3}	=	26	0.09
Utility Power - TOTAL	370 Kw/Hr.	=	--	--

INPUTS (continued)

		MJ	% Of Total
Lighting internal (including Univents)	270 KW/Hr. =	973	3.26
Power	10 Kw/Hr. =	36	0.12
*Lighting and power external	90 Kw/Hr. =	324	1.09
Occupancy 2,234 O.H.	= 223.4 Kw/Hr. =	805	2.69
Solar 36 W M^2 (3380 M^2)	= 292 Kw/Hr. =	1,050	3.52
	TOTAL INPUT	29,823 MJ	100

CONSUMPTION--24 HOURS

Steam boiler, overall inefficiency	17,335,000 BTU =	18,289	61.33
Steam boiler pilot flame inefficiency	1,508,000 BTU =	1,591	5.33
Roof 2751 M^2)	=	3,863	12.95
Walls 1040 M^2)	=	2,457	8.24
Glass 150 M^2)	=	1,582	5.30
Exhaust fans and toilet exhaust	363,000 BTU =	383	1.28
Infiltration normal	480,000 BTU =	506	1.69
Infiltration during loading	300,000 BTU =	317	1.06
*Power-motor inefficiency car plugs	90 Kw/Hrs. =	324	1.09
DHW heating inefficiency 85% =	283,000 BTU =	295	0.99
Utility - Cold Water Cooling 2,000 Gallons @ 5°C Rise	= 180,000 BTU		
	=	190	0.64
DHW 50 gals. loss down drain (50%)=	25,000 BTU =	26	0.09
	TOTAL CONSUMPTION	29,823MJ	100

Notes: * Items indicated have no thermal effect on building.

ENERGY BALANCE--ROLAND MICHENER MODEL

From school statistical data Forms S1, S2 and O1, and using a relatively calm day on January 18, 1979, we obtained the following data based on the knowledge of:

1. Degree days 23.7 S. wind average 12.5 Km/Hr. 8.1 hrs. sunshine.
2. Average ambient temperature -5.7°C. (21.7°F). Snow on ground 2 cm.
3. Indoor temperature 24 hours. 21°C (70°F). There is presently no night set-back.

INPUTS--24 HOURS

Utility - Natural Gas Consumption 23,900 Ft.^{3}

		MJ	% Of Total
Hot water boilers	23,534 Ft.^{3}	= 24,711	67.75
Domestic hot water heater 55 gallons	366 Ft.^{3}	= 384	1,05
Domestic hot water--water heat to building	27.5 Ft.^{3}	= 29	0.08

Utility - Power and Light Total (AV) 1400 Kw/Hrs.

Lighting internal 960 + 100	= 1060 KW/Hr.	= 3,816	10.46
Power motors	190 Kw/Hr.	= 684	1.87
*Lighting and power external	150 Kw/Hr.	= 540	1.48
Occupancy 3,085 OH	= 308.5 Kw/Hr.	= 1,110	3.04
Solar @ 36 WM^2 (4940 M^2)	= 1444 Kw/Hr.	= 5,200	14.26
	TOTAL INPUT	36,474 MJ	100

CONSUMPTION--24 HOURS

HHW boiler - combustion inefficiency	(30%)	= 7,020 MB	= 7,371	20.21
HHW boiler idle boiler and combustion air loss	(30.2%)	7,120 MB	= 7,462	20.46
Roof 4128 M^2)		6,180 MB	= 6,489	17.79
Walls 1626 M^2)		3,510 MB	= 3,685	10.1
Glass 24 M^2)		200 MB	= 210	0.57
Exhaust fans and toilet exhaust - 10 hours		5,200 MB	= 5,460	14.97
Infiltration normal - 20 hours		2,400 MB	= 2,520	6.91
Infiltration loading - 4 hours		2,000 MB	= 2,100	5.76
*Light and power car plugs - 150 Kw/Hrs.		512.5 MB	= 538	1.47
DHW heating inefficiency (.85)		= 311 MB	= 327	0.90
Utility - Cold Water Cooling 3,000 Gallons @ 5°C Rise 270 MB			= 283	0.77
DHW 55 gals. loss down drain	(50%)	= 27,5 MB	= 29	0.08
		TOTAL CONSUMPTION	36,474MJ	100

Notes: * Items indicated have no thermal effect on building.

DESIGN HEAT LOSSES

The monitoring of gas heating fuel in relation to degree days provides a valuable check on the capacity of the heating system.

It is reasonable to establish empirical "Design" values for a given school from printout utility data. Once correction factors are established for windchill, precipitation and other extreme weather conditions, gas consumption per degree day figures can be extrapolated to give required usage at the design figure of -35°C or 53 degree days for Calgary.

Briar Hill Model

From February 23, 1979, the day used in Energy Balance, we obtain:

MCF/DD of 25.22 = 0.6136.

MCF required @ 53DD = 0.6136 x 53 = MCF per day @ design temperature = 32.52

From a more accurate analysis of the Energy Balance:
Boiler output to school = input - losses = 24386 - 18289 = MJ/day = 6096

Heat loss from school = consumption losses - chimney losses = MJ/day = 9324

Heat loss affected by delta T @ 53 DD = MJ ---------- = 11745

Total heat loss including drain losses = MJ ---------- = 11961

Note: this is the school design heat-loss per day

MCF required input to meet this loss = 23113 x 11961/9234 = 29.65.

Boiler firing capability @ 2250 CF/hr. = MCF/day ---------- = 54

Therefore, the boiler is only 55% committed or 82% oversized.

Roland Michener Model

From January 18, 1979, day used in Energy Balance we obtain:

MCF/DD of 23.9 ---------- = 1.008

MCF required @ 53DD = per day at design temperature ---------- = 53.44

From a more accurate analysis of the Energy Balance:

Boiler output to school = MJ/day = input-losses = 24711
= 14833 ---------- = 9878

Heat loss from school = MJ/day = consumption losses
- chimney losses ---------- = 20776

Heat loss affected by delta T @ 53DD = MJ/day ---------- = 45763

Total heat loss including drain losses = MJ/day ---------- = 46075

Note: This is the school design heat loss per day.

MCF required input to meet this loss = MCF/day = 2354
x 46075/20776 ---------- = 52.19

Boiler firing capability @ 3600 MBH = MCF/day ---------- = 74

Therefore, the boiler is 70% committed of 43% oversized.

Summary: Using MCF/DD from utility inputs incurs an error of 9% for Briar Hill and 2% for Roland Michener, both on the safe side.

IDENTIFYING THE MOST PROMINENT ENERGY COMPONENTS

The most prominent energy components have been previously established from the "input" and "consumption" components. However, for comparison purposes, it is of advantage to express the utility energy inputs separately in terms of an energy budget.

THE ENERGY BUDGET

The energy budget is defined as those components of expended utility energy required to maintain an acceptably comfortable environment within a building. As such, these components do not total to the same quantity as the energy audit simply because of the "free" items of solar and occupant heat gain. Water is also omitted from the energy budget, but is listed elsewhere as a utility to be conserved because of cost.

The energy budget is compared to "control" schools deemed equivalent in type and area and also to the Federal energy budget. The figures given in the following table are taken from annual utility records and also represent values taken before the energy-saving modifications were introduced.

IDENTIFYING THE ENERGY-SAVING MODIFICATIONS

A major objective of this study was to supply a "shopping list" of items which would provide the greatest savings for least investment cost. The decisive factor on the order of implementation of modifications was the time-line imposed by the overall program and the subsequent inability to monitor the installed modifications with a reasonable degree of accuracy. This meant that those items easiest to install and monitor were installed first. An attempt was made by calculation, as submitted in a previous report, to establish those items of greatest cost-benefit. Modification numbers were given to identify the items for the installing contractors, and therefore, all modifications continue in this numerical order.

For a priority "Shopping List" of energy saving items, see the following section, titled "Return on Investment".

The compilation of the "Shopping List" constitutes the best summation of monitoring data and estimations that were obtained from past records, and from schools included in this study. Potential savings figure strongly in this report because of the evident areas of wasted energy. Modifications addressed this area of need could not be effectively introduced during the winter heating months and were installed during summer shut down.

Some modifications were monitored only for a few days and the effect projected for the full year. The accuracy of the "Return on Investment", which took place during milder temperature days, is conservatively estimated. Subsequent monitoring data continuing for a full year will verify whether ROI data is as conservative as claimed in this report.

ENERGY BUDGET DISTRIBUTION - $MJ/M^2/YR$

SCHOOL - MODEL YEARLY BASIS	GAS HEATING 5330 DD	LIGHTS 200 DAYS	POWER 365 DAYS	DOMESTIC HW 200 DAYS	CAR PLUG-INS 60 DAYS	TOTAL SCHOOL YEAR	% IN EXCESS OF FEDERAL GUIDELINES
Briar Hill	1143.	70.7	4.8	25.5	7.1	1251.1	
2751 M^2	91.36%	5.65%	0.38%	2.04%	0.57%	100	39%
Capital Hill	1150.	131.	5.	25.5	7.5	1320.	
2751 M^2	87.12%	10%	0.38%	1.93%	0.57%	100	47%
Roland Michener	1338.7	185	60.5	18.6	7.8	1610.6	
4128 M^2	83.12%	11.49%	3.76%	1.15%	0.48%	100	79%
Col. Fred Scott	1615.	183.	61.	19.	8.	1886.	
4130 M^2	85.63%	9.7%	3.24%	1%	0.43%	100.	110%
Cedarbrae	1550.	175.	58.	17.5	7.7	1808.	
4605 M^2	85.73%	9.68%	3.2%	0.97%	0.42%	100.	100%
Federal Guidelines	693.7	136.8	36.	26.3	72.	900 (250 Kw hours)	
	77.1%	15.19%	4%	2.91%	0.8%	100	

Notes: These comparisons were taken during January, February, 1979 during which period the degree days exceeded the average by 21.3%. The last three schools above, have airconditioning, but this was not measured as of 1979. Items #1 and #4 will represent the total gas utility for the year. Items #2, #3, and #5 will represent the total electrical utility for the year.

Modification items, which were too late to be implemented, are also included in the descriptive list as being worthy of inclusion at a future date. Items are identified and where monitored utility rate differences could not be detected, savings data were calculated where possible and are deemed reasonably accurate.

Individual monitoring of more than 20 modifications was not practically possible so overall savings were obtained from utility saving print out data and shared amongst the major contributors.

Each modification can have a relevant effect on each other and therefore, cannot be summed as to energy-saving effect. Every modification should be carefully checked as to side effect on the overall system (e.g.) cutting down water usage during the winter can be cause for frozen water mains, and encrustation of urinal surfaces. No modification should be installed which inhibits the safe operation of the building plant, or which unduly complicates the control systems. For this reason central control of boilers, fans shut down etc., were not installed at this date.

All modifications should be checked with the local codes for compliance with regulations. All modifications should be reversible, if practically possible so that unforseen adverse effects can be cancelled. Check on modifications after significant events such as pre-Christmas assemblies, vacation shut-downs, power failures, blizzard or hoar-frost conditions.

During energy audits and operational system checks, it quickly became obvious that the school plant does not operate as per the design objectives and in many cases had not been fully commissioned. Regardless of energy savings some modifications should be instituted for promotion of plant longevity. These are noted.

The list of modifications follow in numerical order.

BRIAR HILL MODEL - MODIFICATIONS

Modification No. 1

Dual Speed exhaust fan control via master boiler room time-clock to limit fan operation to initial 1/2 hour of classroom occupancy morning and afternoon and on manual demand thereafter. The object is to limit exhaust air, and consequently fresh air intake, to a minimum. The high speed of fan to be locked out at all ambient temperatures below 55°F.

Modification No. 2

Univents to be adjusted for correct ASHRAE cycle No. 2, so that only minimum fresh air is introduced as per code. This modification requires the installation of a reliable discharge-air limit thermostat of the equalizing type as far down stream as possible. The object of this modification is to achieve minimum fresh air at all times with minimum use of energy. ASHRAE cycle No. 2 for univents utilizes the minimum amount of energy. ASHRAE cycle No. 2 for univents utilizes the minimum amount of fresh air

and as such, has about half the energy requirement of cycle No. 3 which is the variable fresh air cycle. From a maintenance view point, cycle 3 is easier to control and is more free of the danger of coil freeze up, so changing cycles must be done with due cognizance of the dangers involved.

Modification No. 3a

A power burner was proposed for more-efficient combustion. If this was installed now, it would nullify the effects of modifications 3a, 9 and 7 already implemented. Instead, it was proposed that power burners be installed in a comparative school and the effects monitored.

Eugene Coste Elementary was one of the latest schools to be fitted with power burners in the summer of '79. Preliminary monitoring data, taking into account initial service problems and degree day variance, indicated a gas saving (electric power excluded) of 15%. This figure has been adopted in this study.

Modification No. 3b

A lower cost alternative to power burners is as follows:

Divide gas burners into 3 stages by installation of 2 electrically operated gas valves cycled off the boiler pressure stat. The object is to keep the boiler off-cycle as short as possible. The three stage flame initially proved to be energy-wasteful because the single flame acted like a large pilot which merely used gas without raising steam pressure. The effects of utilizing 2 and 3 flames has not been effectively monitored as yet.

Modification No. 4

Install time delay switch on Boys' and Girls' toilets entry door to control lights, exhaust fan, and boys' urinal water supply. Control to be instant "on" and 1/4 hour time delay off.

The washrooms installed with this modification tend to become quite cool over the weekend and must be checked for danger of freezing.

Modification No. 5a

Install thermostat "cheater" so that on room lights switch-off, the "cheater" is turned on to heat the thermostat environment and consequently call for reduced room heating. Results were calculated based on reduced room temperature to 16°C. A differential temperature chronotherm was used in place of the "cheater". Changeover was effected by a relay from room lights. The effect of subsequently altered settings in relation to the existing room thermostat nullified the objectives of this modification.

Modification No. 5b

Install alternate night-time thermostat in conjunction with an outside ambient thermostat. This item has not yet been installed.

Modification No. 6

Vestibule heaters were installed with valve and thermostatic control. Results are too small to monitor; those presented are estimated.

Modification No. 7

Discharge main building exhaust via boiler room relief damper to outside. The main exhaust fan is 2 stage and the first stage air quantity is 100% used to pressurize the boiler room and offset combustion air "cold-dump" into the boiler room. During second stage fan operation, the discharged air is automatically dampered so that the balance of building exhaust air is discharged to roof in the normal fashion.

An additional object of this modification is the secondary use of air which is otherwise wasted. The effect on combustion air settings on the boiler must be carefully checked both visually and with flue gas analysis.

Modification No. 8

Weatherstrip outside doors in 4 places. The effects of this are too small to be monitored. Calculations are based on crack-method of infiltration.

Modification No. 9

The combustion air intake was dampered so that a call for firing first opened the motorized damper. On proof of damper open, the gas valve opens and firing begins. The object is to reduce cold air dump into the boiler room and consequent syphoning up the 28" diameter chimney during off-cycles immediately after firing shut-down.

Modification No. 10

Reduce domestic hot water temperature setting to 43°. Savings unable to be measured: calculated only on basis of hand basins used and compared with Roland Michener model which was monitored.

Modification No. 11

Remove ballasts from inactive lights.

Modification No. 12

Reduce lighting levels in classrooms and corridors. Remove tubes only. This item is calculated.

Modification No. 13

Roof over sky lights and remove heating below sky light. Install fluorescent lighting to provide illusion of sky light. This modification has been instituted as a result of building quality restoration programme (BQRP) and has not been monitored as to effect.

The following items are listed for possible inclusion at a future date:

Modification No. 14

Car plug-in circuits to be separated and cycled off the central time clock and thermostatic control.

Modification No. 15

Install energy-saving sodium or low-wattage, wide-band illumination. A separate study is necessary to determine if these items are more cost-effective than removal of tubes and ballasts.

Modification No. 16

Install heat recovery items on boiler chimney and all exhaust fans. This item requires separate study.

Modification No. 17

Introduce a Thermography study of the building interior and exterior to determine major heat leakages.

Modification No. 18

Remove existing boiler and install more-efficient steam raising system. This requires an appraisal of the estimated school life as well as the existing boiler.

ROLAND MICHENER MODEL - MODIFICATIONS

Modification No. 1a

Modify control system so that increased discharge temperature automatically closes OSA damper to minimum and raises mixed air temperature before

preheat coil valve opens. The object of this modification is to reduce induction of outside air to minimum, while there is a general demand for heating. This item modifies the constant air volume cycle more towards ASHRAE cycle No. 2.

Modification No. 1b

Replace Return Air exhaust dampers with 90% shut off dampers and separate Return Air damper control from outside air control. The return air exhaust dampers shall be controlled from static pressure control local to, and 3m. from return air silencers.

The object of these modifications is to prevent induction of outside air and also allow for differences of exhaust and outside air induction due to remote toilet exhausts. This modification is also intended to correct a poor ducting arrangement between discharge and outside air intake.

Modification No. 2

Provide for operation of return air fan only during unoccupied hours. The object is to save fan energy by allowing the shut down of main supply fan, and also pressurize the mixed air damper system to prevent local hoar frost build up.

This modification presumes that the building is reasonably free of infiltration gaps of freeze-prone piping in the ceiling space.

Modification No. 3

Install door switch on boys' and girls' washrooms to instantly switch on exhaust fan, lights and boys' urinals water supply. Time delay to switch off after 1/4 hour operation. This is also a modified vandalism control measure. Washrooms installed with this modification tend to become quite cool over the weekend and must be checked for danger of freezing.

Modification No. 4

Install two-speed primary fan motor for modified variable volume effect. The object is to provide less air during the heating season since air mass is designed for summer conditions. There was also excessive air noise in this system. Control measures must be introduced to prevent operation at low volume during the cooling season.

Modification No. 5a

Install thermostat "cheater" in selected classroom to operate when room lights are switched off. This item has not been installed.

Modification No. 5b

Provide pressure reducing valve in control air line to room control thermostats to provide general night set-back of classrooms. This does not work as reduced air pressure usually opens radiation valves to increase room temperature.

Modification No. 6

Provide control system on supply fan so that during winter months, on minimum outside air, that return air fan is shut down to reduce electrical demand.

This must be carefully checked with school personnel so that door closures caused by increased positive pressure are not a danger to students' fingers.

Modification No. 7

Install variable-volume terminal units in selected staff and conference room areas to reduce air supply to areas when unoccupied. Only a few terminal units can be installed on a constant air volume system without major additions to the control system and fan volume variation.

Modification No. 8

Install indoor-outdoor temperature compensation to automatically raise discharge temperature as outdoor temperature drops. The object of this modification is to provide a modified form of load-analyser system result.

Modification No. 9

Set down boiler water temperature from master time clock in boiler room, to provide increased boiler efficiency.

Indoor-outdoor controller already resets boiler water temperature and any further reduction would be dangerous to piping in remote areas.

Modification No. 10a

Install control damper on combustion air intake so that combustion air is induced only on a call for boiler firing. The general cold-air dump will also be reduced and heat transfer to idle-boiler chimney stack will be lessened.

Modification No. 10b

Install ductwork from return air discharge plenum to combustion air inlet

plenum. The object is to make use of exhaust air for combustion and lessen the cold-air dump from the combustion air-intake.

Modification No. 11a

Reduce domestic hot water (DHW) setting to 43°C.

Modification No. 11b

Switch off DHW recirculation pump during unoccupied hours via master boiler room time clock and recirculation thermostat.

Modification No. 12a

Reduce lighting level in all areas. Remove tubes only to reduce electrical demand for a minimum cost of modification. Lighting levels to be checked with light meter and effects on students monitored.

Modification No. 12b

Remove light ballasts from fixtures where tubes have been removed.

Modification No. 13

Install separate wiring to outside parking plug-ins so that a time clock and thermostatic control can be implemented from the central boiler room control.

Modification No. 14a

Install fail-safe flow switches on existing boiler return shut-off valves. The object of these is to limit water flow through the idle boiler and reduce heat transfer losses. The fail-safe provision is to prevent boiler firing until respective valve is open.

Modification No. 14b

Pump shut down when boiler water is below minimum point (i.e.) for summer shut down.

Modification No. 15

Reduce heating water circulation rate to 60% of design value and trim pump impeller accordingly. The object is to provide only 60% standby as a reasonable alternative to 100% standby in case of break down and thereby achieve energy savings.

Modification No. 16

Install 19mm bypass 20 micron cartridge filter and sight-glass arrangement between pump discharge and suction. This filter, while not inhibiting water circulation continually cleans the HHW supply of rust and boiler water sediment. The savings in energy cannot be measured, but improved heat transfer surfaces and plant longevity is achieved. The main strainer baskets can also be removed after 3 months initial operation and will off-set reduced circulation rate caused by bypass flow.

Modification No. 17

Install power factor monitoring devices and capacitance addition. The diversity of electrically driven devices in future may make this a viable energy saving procedure.

Modification No. 18

Install programmed demand limitation and load-shedding control of electrical energy . The more diverse the electrically driven items, the more savings that can be achieved with this modification.

Modification No. 19

Install energy saving sodium or low wattage, wide-band illumination. These items are becoming more-readily available and may already be a viable alternative to removing tubes from existing fixtures.

Modification No. 20

Install central command monitoring of shut-down or set-back devices instead of time clocks. With the advent of security and alarm installation and 24 hour surveillance, command functions on building operations will become viable.

Modification No. 21

Introduce a thermography study inside and outside the building. This item is covered in another energy study of the school building envelope.

Modification No. 22

Install heat recovery devices, additional solar collection and storage means. This is a very broad subject and involves changing emphasis on heating fuels and systems. Presently, closed-loop water heat-pump systems are being installed in Alberta and they are readily applicable to this subject.

Modification No. 23

Install infra-red and motion detection sensing devices in conjunction with security control to switch room lighting on-off in relation to occupancy.

Modification No. 24

Replace poor indoor-outdoor boiler control so that an adjustable differential is obtained to prevent the present boiler short-cycling.

Modification No. 25

Obtain airconditioning note for electricity and thereby reduce electric utility cost by 5%.

By installing an airconditioning plant of required KVA demand, a revised electrical rate is obtained which allows more use of electrical energy in winter without penalty. This is an energy saving antithesis and should be investigated by federal and provincial authorities. Water-sewer rates do not provide for a credit for irrigation water used for landscape shubbery and this should also be brought to the attention of a utilities commission.

Modification No. 26

Install softener on DHW supply and tie in boiler water make up via DHW.

Modification No. 27

Install separate OSA thermostat so that OSA dampers do not return to minimum position when airconditioning is on, but remain open until OSA temperature reaches 24°C.

Modification No. 28

Increase return air fan speed to give positive pressure on discharge side of R/A fan to balance main fan suction. The main fan can be cause for excessive suction and air pressure imbalance. This can cause the return air fan relief dampers to induce outside air rather than relieve discharge air.

Modification No. 29

Fully commission all items. While this is not technically a modification, it may mean improvements to the existing system in order to function as designed. The extent of commissioning, or lack of it has been discussed elsewhere in this report.

SUMMARY INFORMATION--RETURN ON INVESTMENT

These modification items in ranking order of dollar economy constitute the "ENERGY SAVING SHOPPING LIST" of modifications.

The column marked R.O.I. are items listed in order of greatest Return on Investment. The column marked $MJ/M^2/Yr$ constitutes the actual energy saved as a quantitative item when viewed without economic consideration. The column marked PAYBACK lists the years to recover dollar first cost of modifications. Only summary information is included in these lists obtained from overall monitoring data contained in Volume II.

Formula for Return on Investment data is obtained from:

$$R.O.I. = \frac{S - DC \times 100\%}{F.C.}$$

Where: S = Net annual utilities Savings in dollars.

DC = Depreciation Changes dollars per year = $\frac{FC}{EL}$

EL = Estimated Life remaining Briar Hill = 15 yrs. Roland Michener = 30 yrs.

FC = First Cost of modification (labour and materials).

Pay back period in years = PP = $\frac{FC}{S}$ = $\frac{\text{First cost of modification}}{\text{Annual savings of modification}}$

$MJ/m^2/yr.$ is obtained from MCF x 1055 = MJ gas energy/yr.
Kw hrs. x 3.6 = MJ electrical energy/yr.

Total MJ/yr./area of school m^2

Briar Hill = 2751 m^2

Roland Michener = 4128 m^2

GUIDELINES AND RECOMMENDATIONS

Since the detailed recommendations are indicated in the modification lists, only summary comments are expressed in this section. The "Return on Investment" summary also indicates the main points for existing schools which are:

a) Energy Conversion: From natural gas to heat involving heat exchange surfaces is the most significant energy waste. The single boiler plant is the greatest offender and there is clear evidence to suggest that extended-fin water tube boilers of the high-flux type renewed every five years would be a better investment than the large single boiler plant now in use.

- BRIAR HILL MODEL -
ENERGY ECONOMICS SHOPPING LIST

(Based on Estimated Life of 15 Years)

MODIFICATION NOS.	DESCRIPTION	PAY BACK YEARS	ENERGY SAVING MJ/M²/YR	R.O.I. $	REMARKS
10	Domestic HW temperature reduction.	0	5.4	1000.	No cost item
2a	Univents on low fan.	0.3	39.	300.	
12	Remove tubes from lights.	0.5	4.2	200.	
5b	Night set back thermostat and Chronotherm.	0.7	120.	90.	
4	Time delay on washrooms.	2.4	25.	35.	
1	ExH fan off-on time clock.	3.25	60.	25.	
3a	Stage exist. burners.	3.8	126.	19.	
18	New multiple boilers.	5.5	709.	12.	
9&7	Combustion air control and exchange fan via boiler room.	5.6	95.	11.	
2	Univents cycle 2 instead of 3.	8.7	64.	8.5	
11	Remove ballasts from inactive lights.	6.5	2.6	8.	
8	Weatherstrip doors.	7.8	8.6	6.	
3	Power burners.	12.	90.	2.	
16	Heat recovery items on chimney.	12.	190.	2.	
6	Vestibule thermostatic control.	12.5	7.6	1.3	
13	Roof over sky lights.	22.	21.	-ve	Non-economic
14	Car plugs controlled.	20.	--	--	Not recommended
15	Wide spectrum lighting.	--	--	--	
17	Thermography of building.	--	--	--	

- ROLAND MICHENER MODEL -

ENERGY ECONOMICS SHOPPING LIST
(Based on Estimated Life of 30 Years)

MODIFICATION NOS.	DESCRIPTION	PAY BACK YEARS	ENERGY SAVING $MJ/M^2/YR$	R.O.I. %	REMARKS
25	Air conditioning rate.	0	--	1000.	No cost item
11	Reduce domestic HW setting to 43°	0	5.	1000.	No cost item
2	Time clock shut down of main fan only.	0.64	18.	150.	Low cost
12	Reduce lighting levels.	0.6	0.4	150.	Low cost
9	Set down boiler water temperature at night.	1.	15.	60.	
1a	Improve OSA and RA dampers to 90% shut off.	2.1	20.	44.	
14	Shut off water to idle boiler.	2.5	76.	41.	
6	Shut off RA fan during winter daytime.	2.	2.6	40.	
3	Control washrooms on door switch.	2.	24.	38.	
8	Automatically raised discharge air temperature.	2.5	20.	36.	See also No.
15	Reduce Htg. HW pump rate to 60%.	2.7	3.	32.	
5a	Set back all room temperature to 16°C at night.	3.3	127.	26.	All rooms
11a	Switch off recirculation pump with T stat.	4.	2.5	22.	
20	Central command monitor timing.	4.	3.5	20.	
1	Return OSA dampers to min. during heating.	4.6	56.	18.	
10a	Utilize RA fan to temper combustion air.	5.5	39.	15.	
24	Improved boiler water temperature control.	5.7	5.7	14.	
4	Install two-speed supply air fan motor.	6.	25.	13.	
13	Parking plugs timed off with T stat.	6.	3.	12.	
10	Install auto damper on combustion air.	7.	9.	11.	
27	OSA damper to min. when OSA is 24°.	7.4	0.4	10.	
12a	Remove unlighted ballasts.	8.	2.	7.	
16	By-pass filter on circulation pump.	11.4	5.6	5.	

ROLAND MICHENER MODEL (continued)

MODIFICATION NOS.	DESCRIPTION	PAY BACK YEARS	ENERGY SAVING $MJ/M^2/YR$	R.O.I. %	REMARKS
18	Demand limit - pumps off when A/C on.	14.	0.2	4.	
17	Power factor improvement.	14.	4.	3.5	
14a	Shut off pumps when OSA is above 20°.	21.	0.7	2.	See also 18
7	Install variable volume terminal unit.	29.	120.	1.	One room
19	Install sodium lighting.	--	--	--	
21	Thermography study of building.	--	--	--	
22	Heat recovery-storage-solar.	--	--	--	
23	Infra-red switching of lighting.	--	--	--	
26	Softener on boiler and air washer.	--	--	--	Maintain advantage
28	Increase R/A fan speed.	--	--	--	See also 1a
29	Fully commission all items.	--	--	--	

b) Primary Air Movement: The modern accent on fresh air ventilation and consequent requirements of make-up air has lead to excessive wastes of energy, particularly if outside air dampers do not provide for 90% shut off. Reliance on the constant air volume reheat system of air distribution has serious energy economy deficiencies.

Air circulation must be reduced on demand—i.e., variable air volume and fresh air introduction must not be a function of the outside air temperature which is the ASHRAE cycle No. 3. Instead ASHRAE cycle No. 2 is recommended which provides constant minimum outside air.

c) Secondary Air Movement: Exhaust air must be regarded as a valuable commodity and used before it is exhausted--i.e., directed to the boiler room for pressurization or temper the combustion air. Heat exchangers will certainly become more economic on exhaust air "run around" systems.

d) Lighting Levels, and Electrical Energy Conversion: Lowered lighting intensities, better wide-bands of colour integrity, and better energy-to-light conversion should be expected from the new lighting technologies now available. Better switching and zoning methods should be investigated to ensure that lights are switched off when rooms are vacated.

Apart from the above four general items, all other areas of energy conservation in existing schools are of secondary order of magnitude. However, one significant item should be re-emphasized here, and that is the full commissioning of all components. This is generally not done and deficiencies in this regard can be found in most schools.

FUTURE TRENDS

It is obvious that Energy Conservation will be an intensified activity in the future. Some areas worth investigating are:

1. More efficient conversion of fuels to heating energy such as closed loop heat pump systems with solar assistance and extended storage capability.

2. Phasing out of non-renewable fuels such as gas and more emphasis on solar and electrical energy.

3. More and better insulation on building envelope and better site orientation.

4. Modular construction allowing for increase and decrease in building utilization.

5. Lighting improvements in terms of energy conservation and quality of lighting.

6. More specific standards in terms of fresh air, odour control, humidity and diversity of temperature control.

7. Greatly accelerated uses of computer programmes such as INTERA, electronic technology particularly relating to security, alarm, vandalism, monitoring and command of building needs, programmed shut-downs, power load-shedding and power-factor monitoring.

8. Heat exchange devices enhancing heat recovery and heat storage.

9. Increased use of infrared thermography for indicating thermal losses.

10. Increased use of infrared detectors as an adjunct to vandalism detection. They could be used for switch on and off of room lighting when bodily vacated.

11. Operation and maintenance program of preventative maintenance.

ZERO BASED BUDGET OF ENERGY

Our comfort expectancies in the school building of the future are going to be subjected to a revised mind-set. New expectations of a comfortable environment will be determined largely by the fuel meter so building occupants can expect to carry more insulation on their bodies than before.

It is most probable that buildings will be allotted a budget for energy use and those exceeding that budget will be penalized.

Each building and its occupancy will largely determine the base budget. However, the setting of the guidelines will be the function of some government department. This means that, in order to keep within the energy quota, the building environment will be allowed to fall as low as practical during the unoccupied hours.

Some factors for establishing that practical low point or zero base are given as follows:

a) Cool Down and Warm Up Times: These are usually equal and opposite and are a function of the building specific mass and the heating system.

b) Perimeter Sensitivity: Items of piping, equipment or furniture that are sensitive to freezing or changes in environment will determine the building low point.

c) Condensation: This is a function of the relative humidity within the space, and although not normally considered in Calgary, considerably lowered temperatures in the building will cause adverse effects in control air lines, painted surfaces, gymnasium floors, windows, fluorescent lights, and paper products.

d) Demand Factors: Thousands of buildings all warming up at the same time will cause the utility companies embarrassment, so penalties and/or incentives will follow to motivate the use of off-peak loads. This will be particularly noticable with electrical demands.

e) Operational Factors: Lowering the indoor environment will adversely affect basements and indoor-outdoor delta temperature. Frost may quickly form in areas previously given only nominal heating. Some schools even now have water flowing continuously during the "heave season" to prevent a water main break.

Reduced water flow due to a utility conservation programme can be cause for other similar problems.

CONCLUSION

Energy conservation has a negative connotation to the uninitiated, but to the practical economist, it is a timely and interesting science, having positive contributions toward building efficiency design and operation.

In this report, the general assumption that energy usage can be plotted with weather and occupancy parameters has been verified. The use of input and consumption statistics has been utilized to obtain useful information on the integrity of building design and operation.

Adapting computer technology to the masses of comparative data can now yield useful information that has been by-passed because of the tedium of calculations involved on 200 or more schools. This study has the possibility of infinite variations only hinted at in this report, and has involved hundreds of man-hours mainly as an adjunct to regular work loads.

For anything of value to be achieved as a result of this study, full time follow-through is required. One final recommendation is therefore suggested, namely, that the services of a consultant or energy conservation specialist be engaged on a full time basis, to evaluate, audit, institute, supervise, monitor and report on energy conservation.

BIBLIOGRAPHY

1. Guidelines for Conserving Energy in Alberta Schools. Planning and Research, Alberta Education, 1978.

2. Calgary Board of Education Energy Analysis, Reid Crowther, 1978.

3. Sweetgrass Study in Energy Conservation.

4. Study in Energy Conservation, Alberta Schools.

5. ASHRAE Fundamentals 1977.

6. ASHRAE Systems 1976 Chapter 43.

7. Canadian Metric Practice Guide, Can 3-Z 234. 1-76.